Agricultural Productivity, Land Use and Species Preservation

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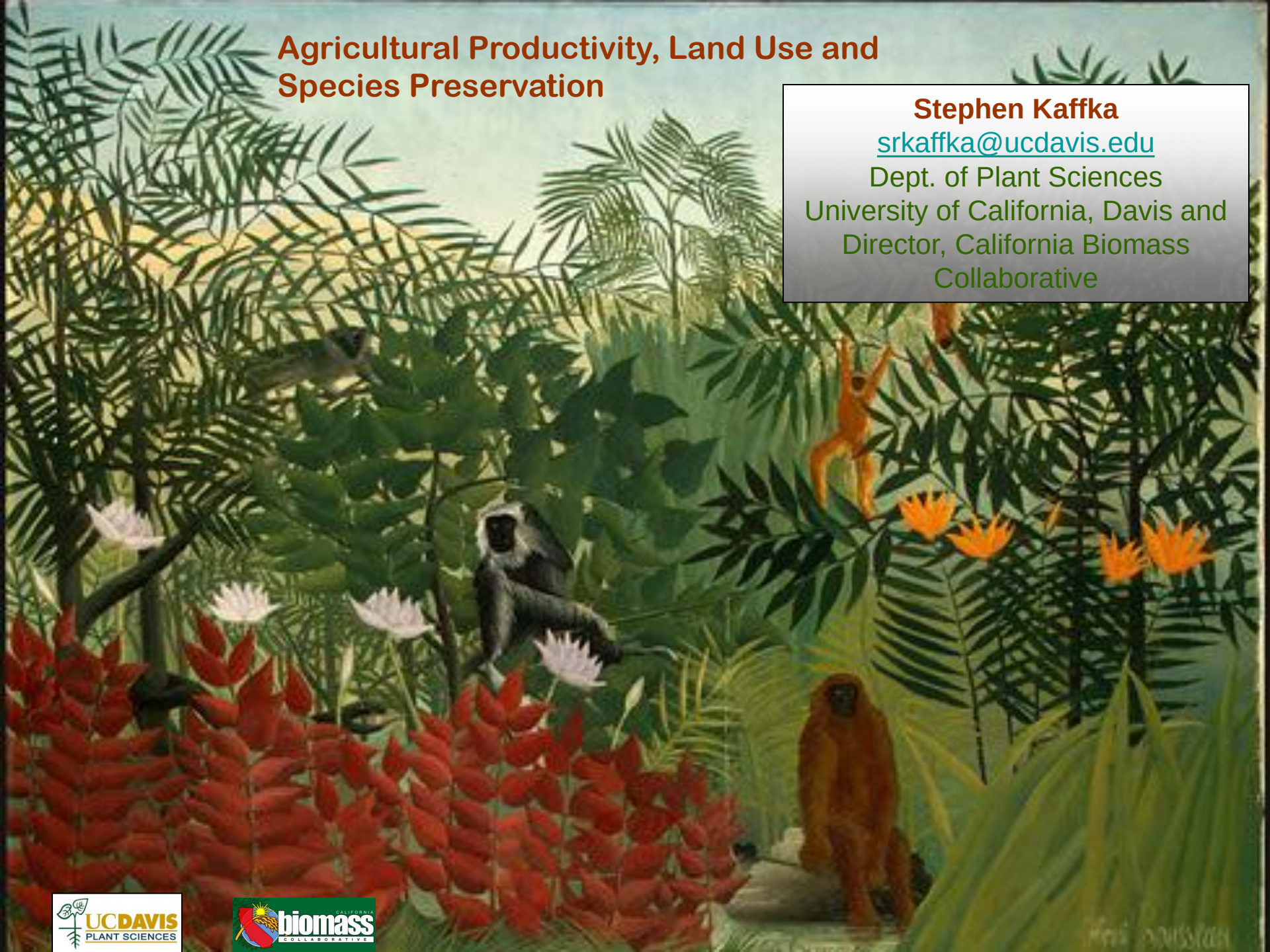


"WHITE WINGS" UNDER POLICE PROTECTION
BOOKBINDER
GATHERING GARBAGE, NEW YORK, UNDER POLICE GUARD

Agriculture has multiple functions

1. To provide an adequate food supply for a growing human population at a reasonable price.
2. To provide an increasingly high quality diet for all the world's people.
3. To maintain the income of farmers at levels comparable to that of the urban population
4. To maintain the natural resource base of agriculture.
5. To use non-renewable resources prudently.
6. To maintain and provide habitat and resources for other species, and to maintain the function of supporting natural ecosystems.

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5. To use non-renewable resources prudently.
6. To maintain and provide habitat and resources for other species, and to maintain the function of supporting natural ecosystems.
7. To produce transportation fuels and other forms of surplus energy from crops and crop residues.

Adding this additional objective leads to a rebalancing of all objectives.

Multiple objectives for biofuels in public policy:

Alternative fuels from biomass will:

1. Diversify the supply of transportation fuels, provide more domestic sources and improve national security
2. Increase rural employment and wealth,
3. **Reduce expensive crop surpluses**
4. Distribute fuel refining
5. Benefit the environment by reducing petroleum use for transportation and GHG increases
6. Other benefits

(DOE, USDA, other sources-2004)

CRITICISM OFF THE ADVERSE EFFECTS OF CHEAP US GRAIN:

"Since the US is the world's largest exporter of cereal grains, its domestic and foreign policy has as significant impact on the world market. US agricultural policy is (was) aggressively targeted at building new market share and promoting international reliance on US food exports.

Import dependency undermines international goals … to encourage food self-reliance and security from hunger.

US export-expansion policies have undermined foreign production capacity, altered consumer preference, and … created dependencies on imports of … grains.

The US …should abandon export subsidies and other practices harmful to international food security."

G. DiGiacomo, Institute for Foreign Policy Studies_1996

What is a more sustainable policy?

"Sustainability, when dealing with humans, means the ability to act on the unavoidable existence of legitimate contrasting views about what should be considered an improvement. Winners are always coupled with losers. To make things more difficult, nobody can guess all the implications of a change."

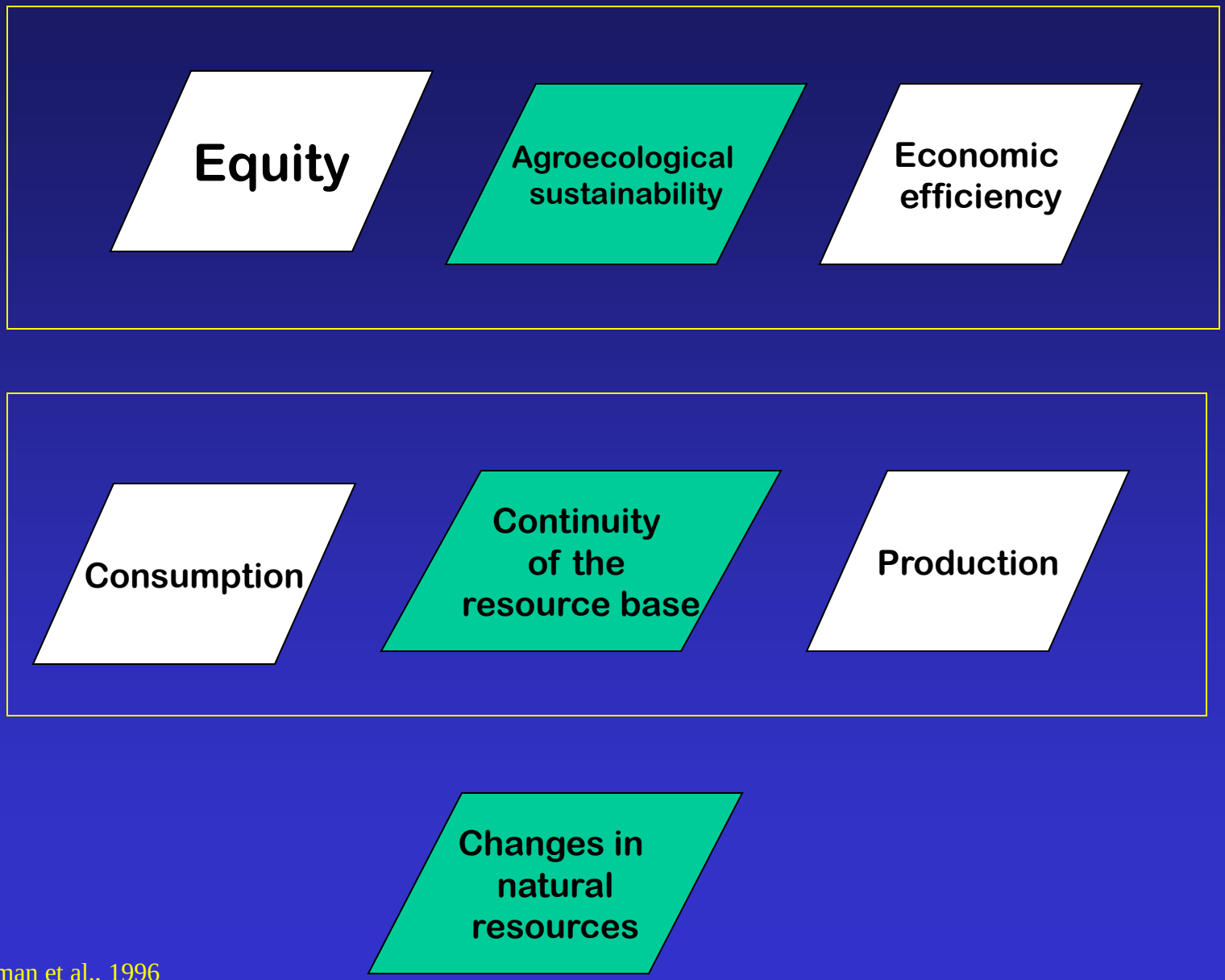
Giampietro, 2004

What is a more sustainable policy?

"Tradeoffs are not always commensurable. When different relevant scales have to be considered simultaneously, when there are several different relevant social groups, and the existence of legitimate but contrasting views are recognized, heterogeneous perceptions of costs and benefits become non-reducible and incommensurate."

Giampietro, 2004

What we call sustainable depends on the boundary conditions and policy objectives



Kruseman et al., 1996

Agricultural Productivity, Land Use and Species Preservation

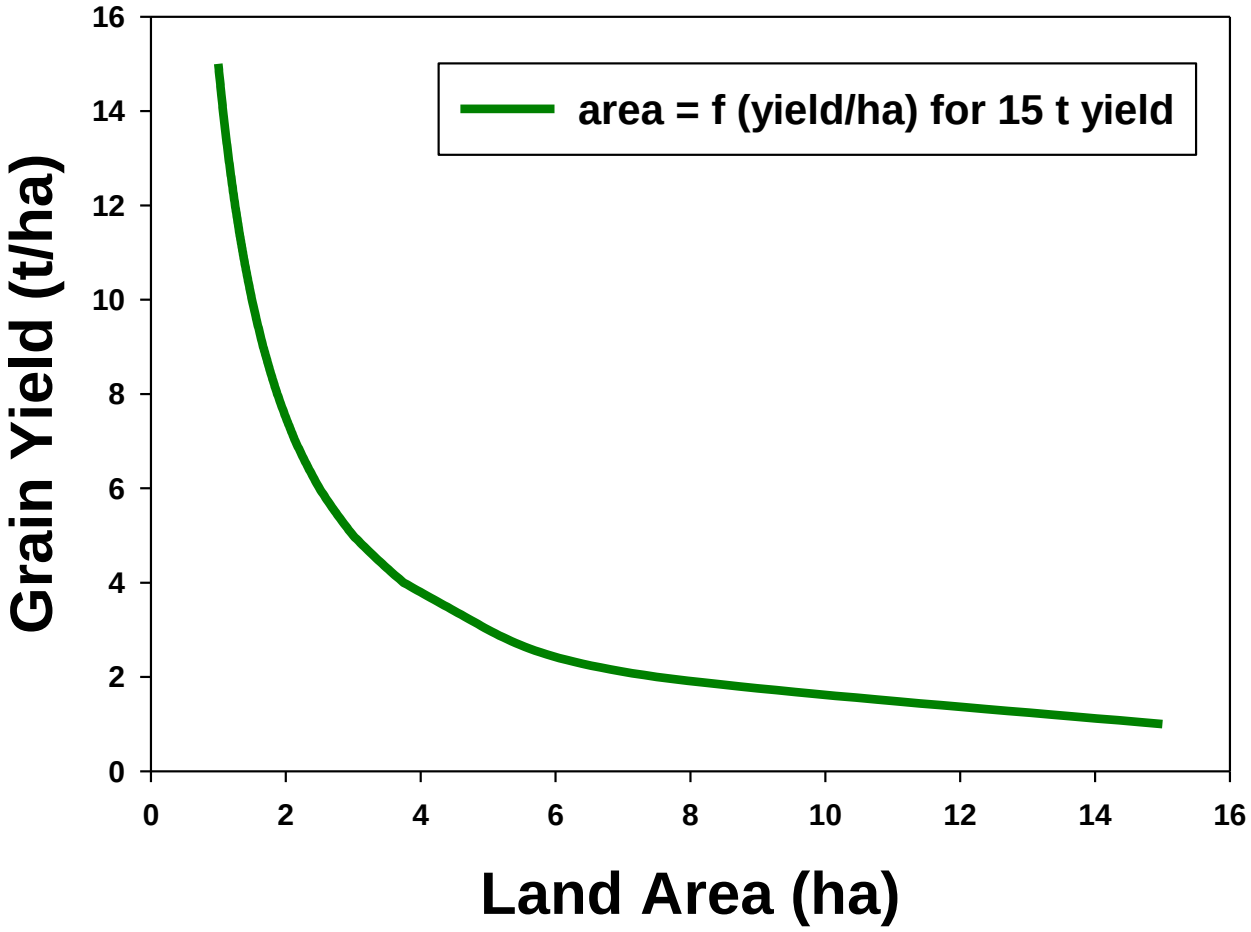
Land Use in Agriculture

Productivity and Technology

Agro-ecological Benefits

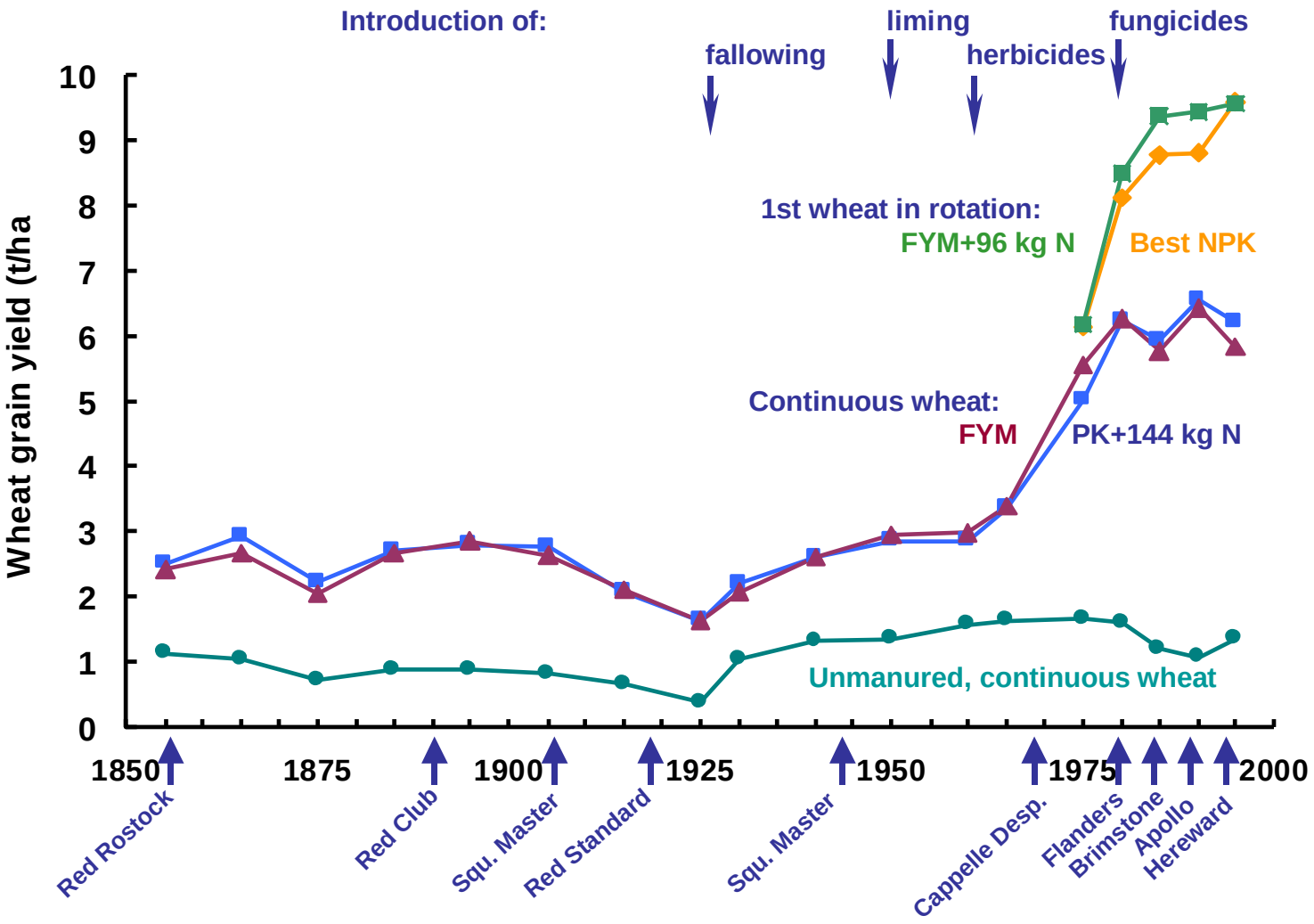
Ecological Risk

The larger the yield per ha, the less land that is needed to meet human food needs

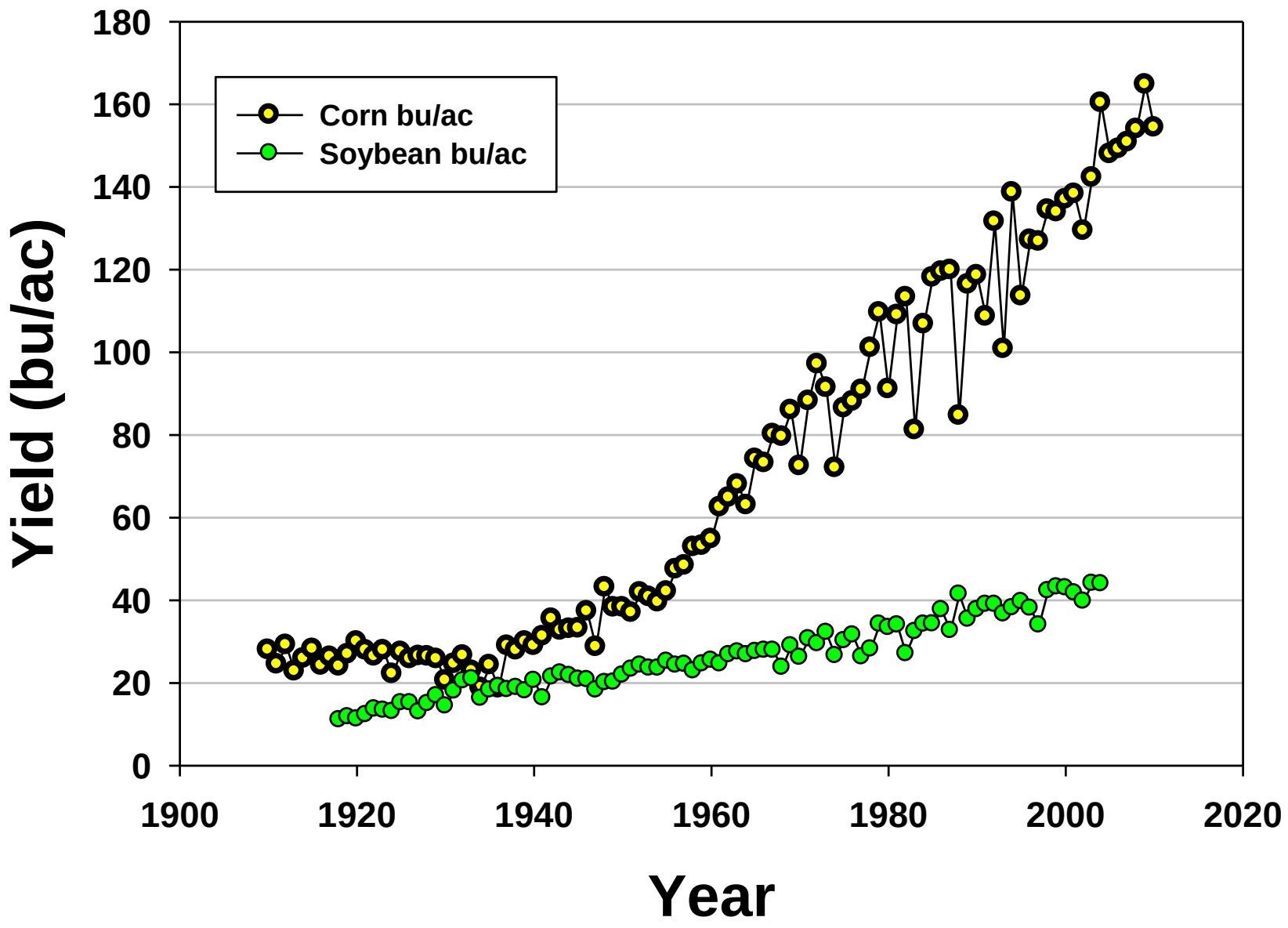


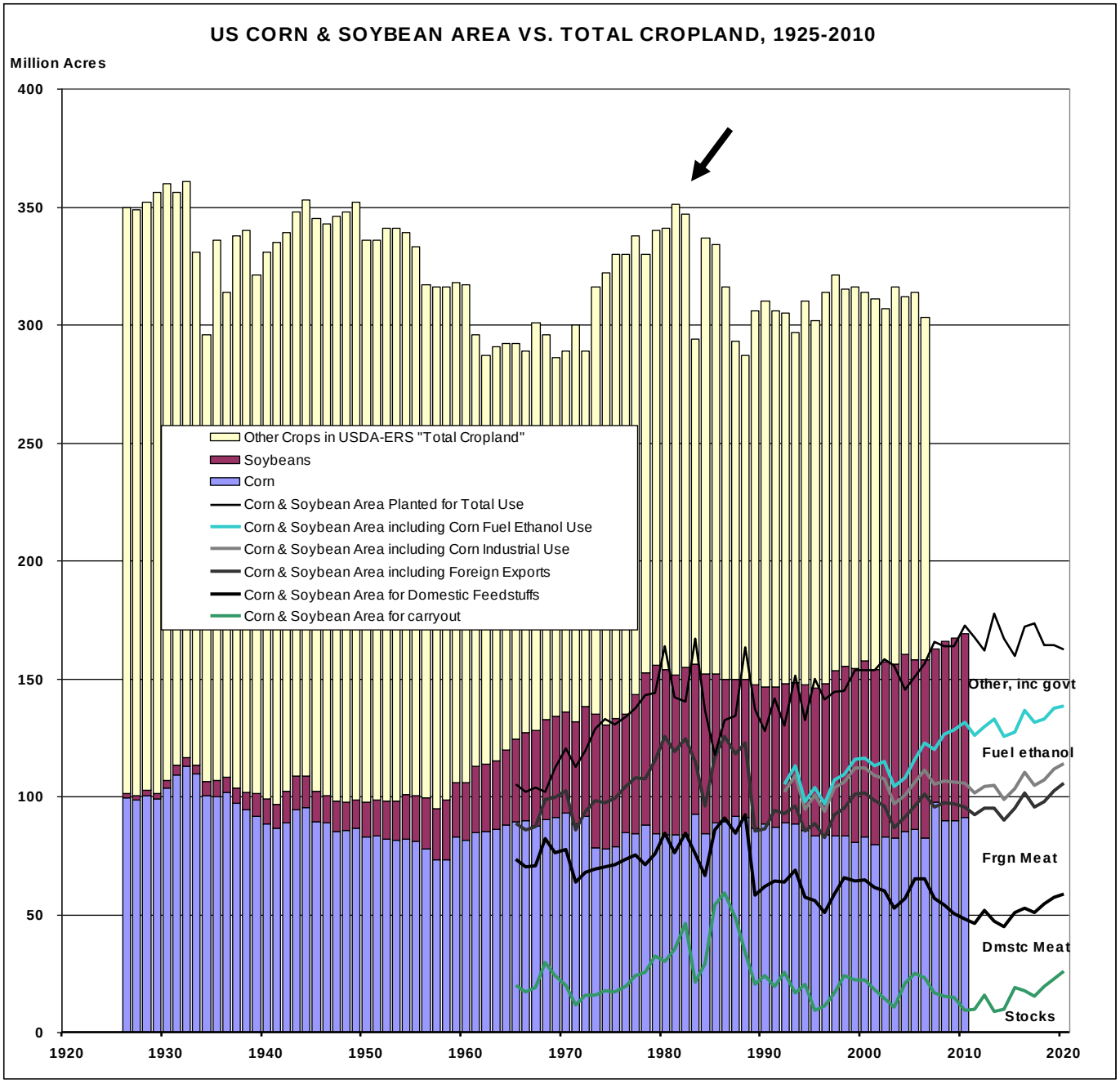
Loomis and Connor, 1992

Long-term winter wheat yield trends, Rothamsted, England



Powlson and Poulton, 2003


Corn and Soybean Yields in the United States/ USDA data
Corn bu/ac
Soybean bu/ac
Yield (bu/ac)
Year
0
20
40
60
80
100
120
140
160
180
1900
1920
1940
1960
1980
2000
2020



Courtesy of W. Hudson, PRX 2011

Agricultural Productivity, Land Use and Species Preservation

- **Total Farmland in the US has declined. Causes: urbanization and other land conversion, government policy (CRP), improved efficiency, retirement of marginal farms and farmland.**
- **The amount of land devoted to soybeans has increased at the expense of other crops like wheat and cotton. Soybean demand in recent years has been increasingly driven by international markets.**
- **Yields have increased significantly for most basic US crops, but especially corn and soybeans.**

Agricultural Productivity, Land Use and Species Preservation

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The ability to improve efficiency is an indicator of sustainability and one basis for a sustainability standard

Outputs		**Inputs**	
	Decreasing	***Constant***	***Increasing***
Decreasing	**Indeterminant**	**Unsustainable**	**Unsustainable**
Constant	**Sustainable**	**Sustainable**	**Unsustainable**
Increasing	**Sustainable***	**Sustainable**	**Indeterminant**

—(Montieth, 1990)

A production factor which is in minimum supply contributes more to crop yield, the closer other factors are to their optimum…No production factor is used less efficiently, and most are used more efficiently with increasing yield levels…

_Liebscher, G. (1895). Journal für Landwirtschaft 43,49.

De Wit (1992): Resource use efficiency in agriculture, Agric. Systems, 40:125ff

De Wit (1992)

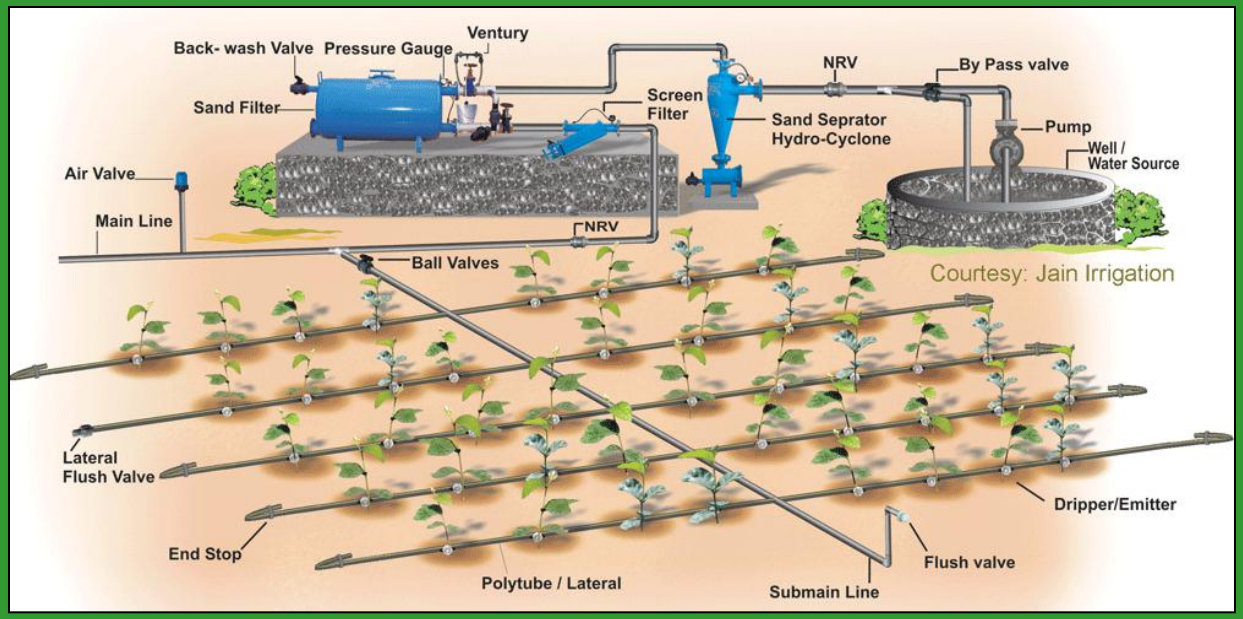
"Leibscher's law reflects the fact that the agricultural production process in low-yielding situations, where many limiting and partially unknown factors interact, is not very well understood and therefore difficult to manage, whereas in high-yielding situations (the law) implies better control so that inputs may be better timed and adjusted to demand. Inputs can be managed better with respect to the environment."

De Wit, 1992, Agric. Sys.

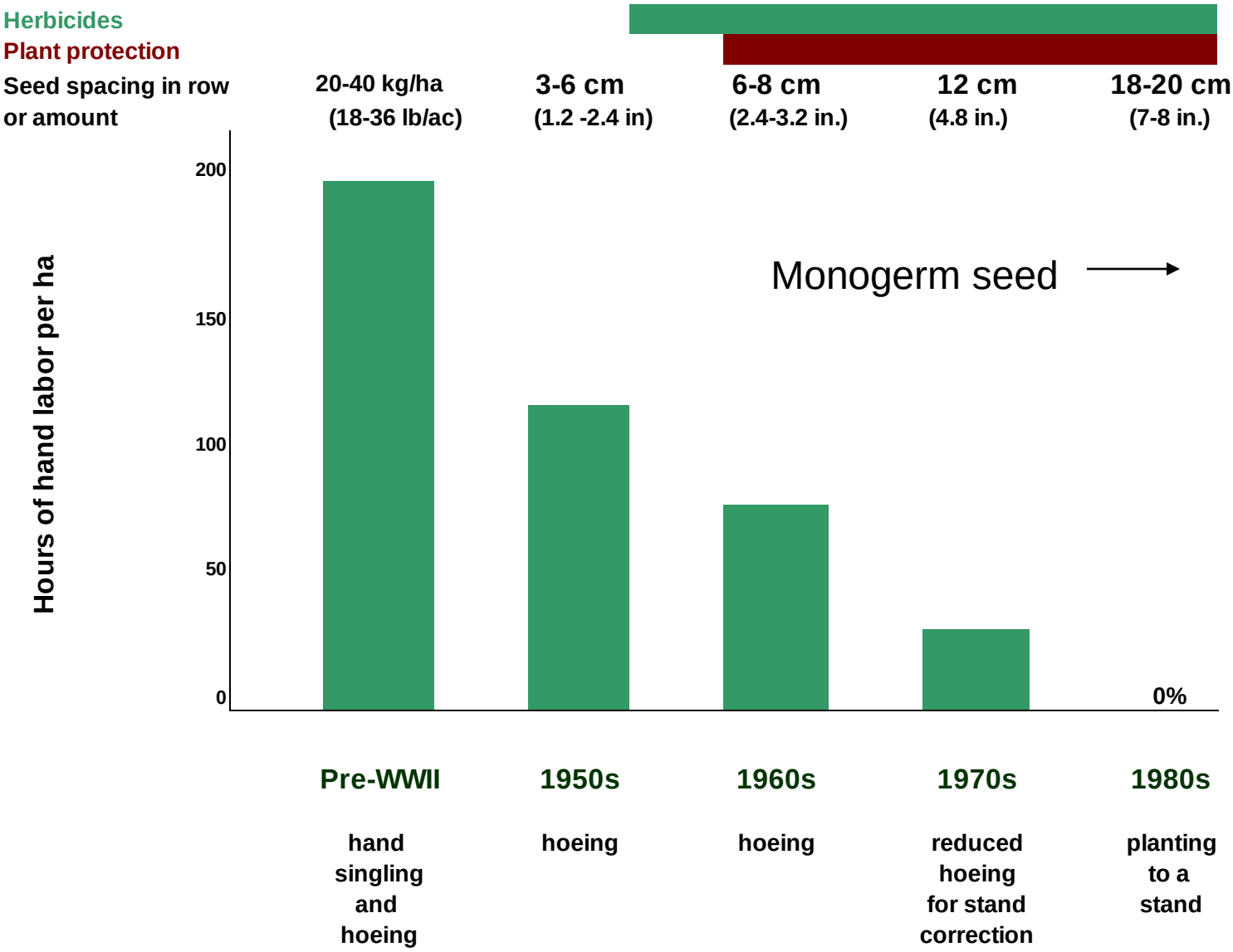
"… a feature of (agricultural) intensification is that it is not the improvement of one growing factor that is decisive, but the improvement of a number of them."

This leads to positive interactions that result in the total effect of all these improvements being larger than the sum of the effects adopted separately.

Drip irrigation



Sugarbeet stand establishment and technology change



Increasing returns to total factor productivity :

The need for nutrients and water, expressed per unit surface area, increases with the yield level,

but decreases when expressed per unit yield.

Increasing returns to total factor productivity :

But other inputs remain the same (or nearly the same) for low and high yield levels (P, lime for pH control, animal maintenance costs in a dairy). Surface area related inputs (tillage for example) are inversely proportional to yield.

De Wit, 1992

"Pollution prevention is best served by concentrating farming in the most favorable regions. The need for energy, fertilizers, and biocides per unit product is then lowest. This relieves the (global) burden on the environment; but, (locally) environmental standards continue to be threatened because of the increased use of resources per unit area in regions where agriculture continues to be practiced."

L. Jackson photo

de Wit, 1992

- **The control of non-obligate pests and diseases may require less inputs in both absolute and relative terms with increasing yields, but obligate pests and diseases may require more inputs for control.**
- **Agricultural research should focus on the pests and diseases that respond to the same inputs that also otherwise increase yields.**

Agricultural Productivity, Land Use and Species Preservation

Land Use in Agriculture
Productivity and Technology
Agro-ecological Benefits
Ecological Risk

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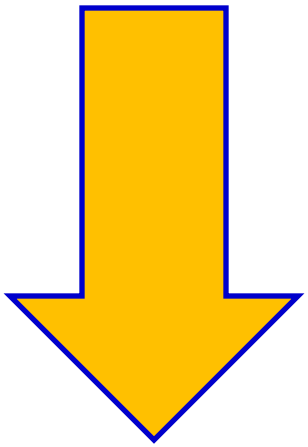
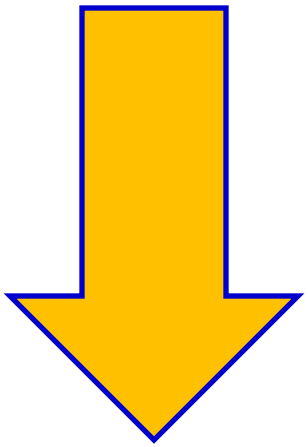
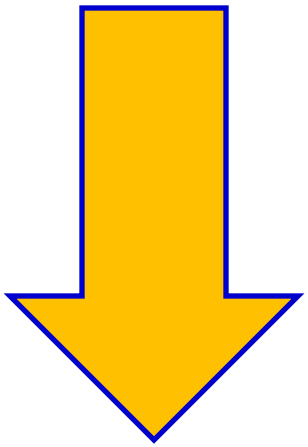
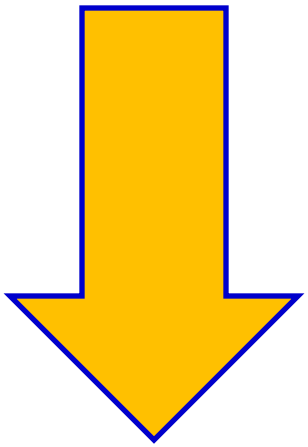
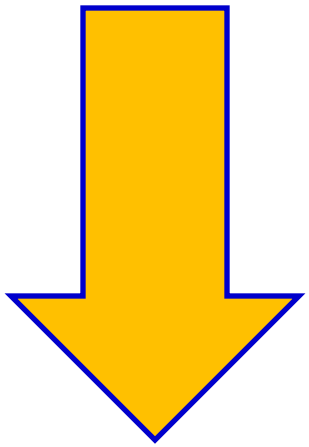
Agricultural Productivity, Land Use and Species Preservation

- **Corn production costs have declined in the United States by 62% over the 30 years.**
- **Corn production volume has approximately doubled over the same period.**
- **Higher corn yields and increasing farm size are most important contributors to this trend.**
- **(Similarly, the cost of ethanol production from corn has declined by 60% due to increased efficiency and economies of scale.)**

Hettinga et al., 2009. Energy Policy, 37:190-203

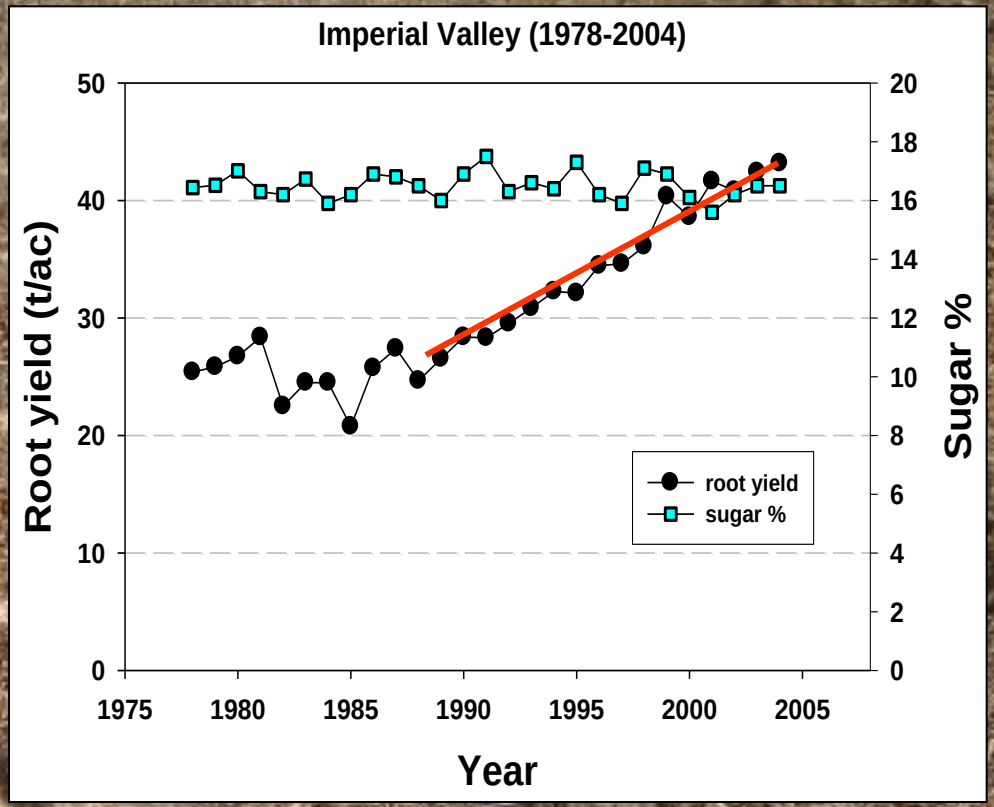
Corn's Impacts, 1987-2007

Land Use	Soil Loss	Irrigation	Energy	Climate
Amount of land to produce one bushel of corn	Soil loss per bushel, above a tolerable level	Irrigation water use per bushel	Energy used to produce one bushel	Emissions per bushel
				
37%	**69%**	**27%**	**37%**	**30%**

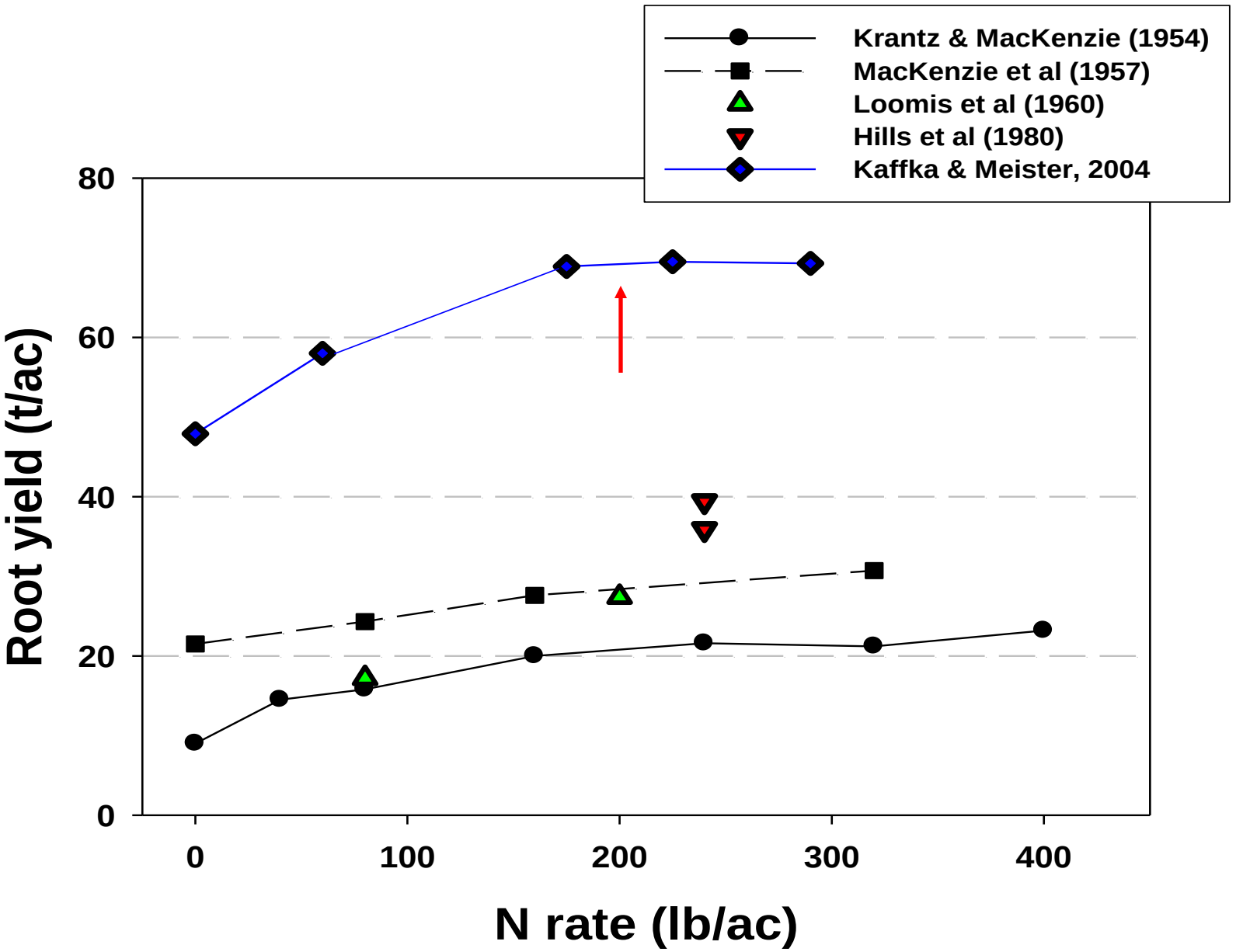
NCGA
www.ncga.com

Imperial Valley, August 2011 harvest

69.6 t/ac roots and 24,550 lbs sugar/ac



Sugar beet yields in the Imperial Valley



Agricultural Productivity, Land Use and Species Preservation

"…We estimate the net effect on GHG emissions of …agricultural intensification between 1961 and 2005...

While emissions from factors such as fertilizer…have increased, the net effect of higher yields has avoided emissions of up to 161 GtC (590 GtCO2eq) since 1961.

(Investments in)… yield improvements should be prominent among efforts to reduce future GHG emissions."

Greenhouse gas mitigation by agricultural intensification. Burney, J.A., et al., 2010. PNAS. On-line

Beneficial Aspects of Biotech Crop Adoption

1. Reduced crop losses from weeds, insects, and diseases,
2. Reduced fuel use for tillage, etc.,
3. Improved worker safety,
4. Less yield variation,
5. Greater management flexibility,
6. Reduced soil erosion and nutrient loss,
7. Reduced pesticide use.

National Academy of Sciences, 2010. The Impact of Genetically Engineered Crops on Farm Sustainability in the United States.

Farm level effects of GE crops_Sexton and Zilberman, 2010

COUNTRY	Yield increase (%)	Insecticide use (%)
Bt cotton		
Argentina	33	-47
China	24	-65
India	37	-41
Mexico	9	-77
US	10	-36
Bt Maize		
Argentina	9	0
Spain	6	-63
Philippines	34	-5
US	5	-8

How agricultural biotechnology boosts food supply and accomodates biofuels

Steven Sexton and David Zilberman

(UC Berkeley)

Working paper 16699

http://www.nber.org/papers/w16699

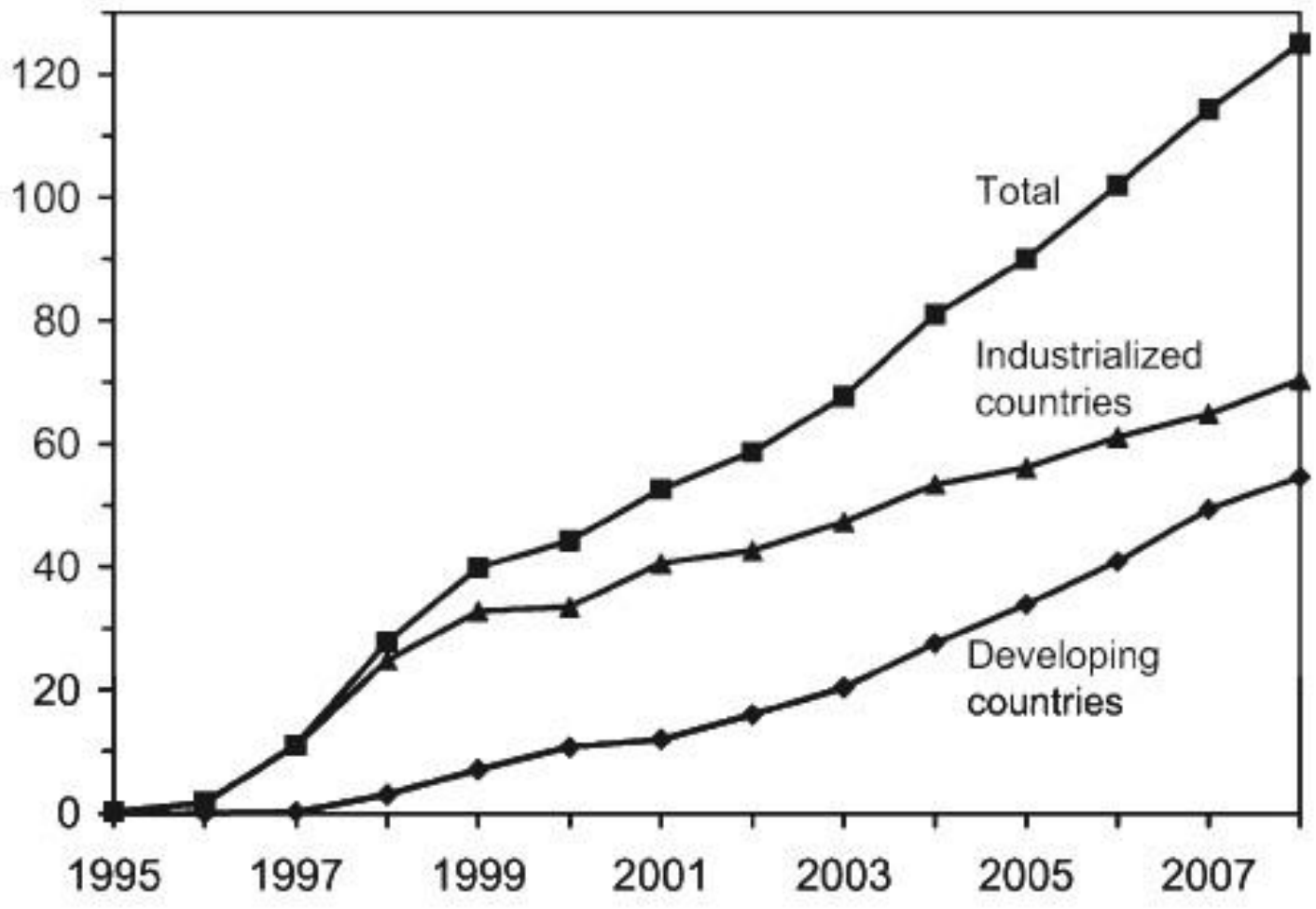
National Bureau of Economic Research

Agricultural Productivity, Land Use and Species Preservation

- Increased global demand for biofuels is placing increased pressure on agricultural systems at a time when traditional sources of yield improvement have been mostly exhausted, generating concern about the future of food prices.
- Estimates of world wide yield gains possible from adoption of GE crops range from 65% for cotton, to 12.4 % for soybeans.
- GE crops …play an important role in arbitrating tensions between energy production, environmental protection, and global food prices.

Sexton and Zilberman, 2010

GE Crop Adoption Over Time Has Been Very Rapid



Sexton and Zilberman, 2010

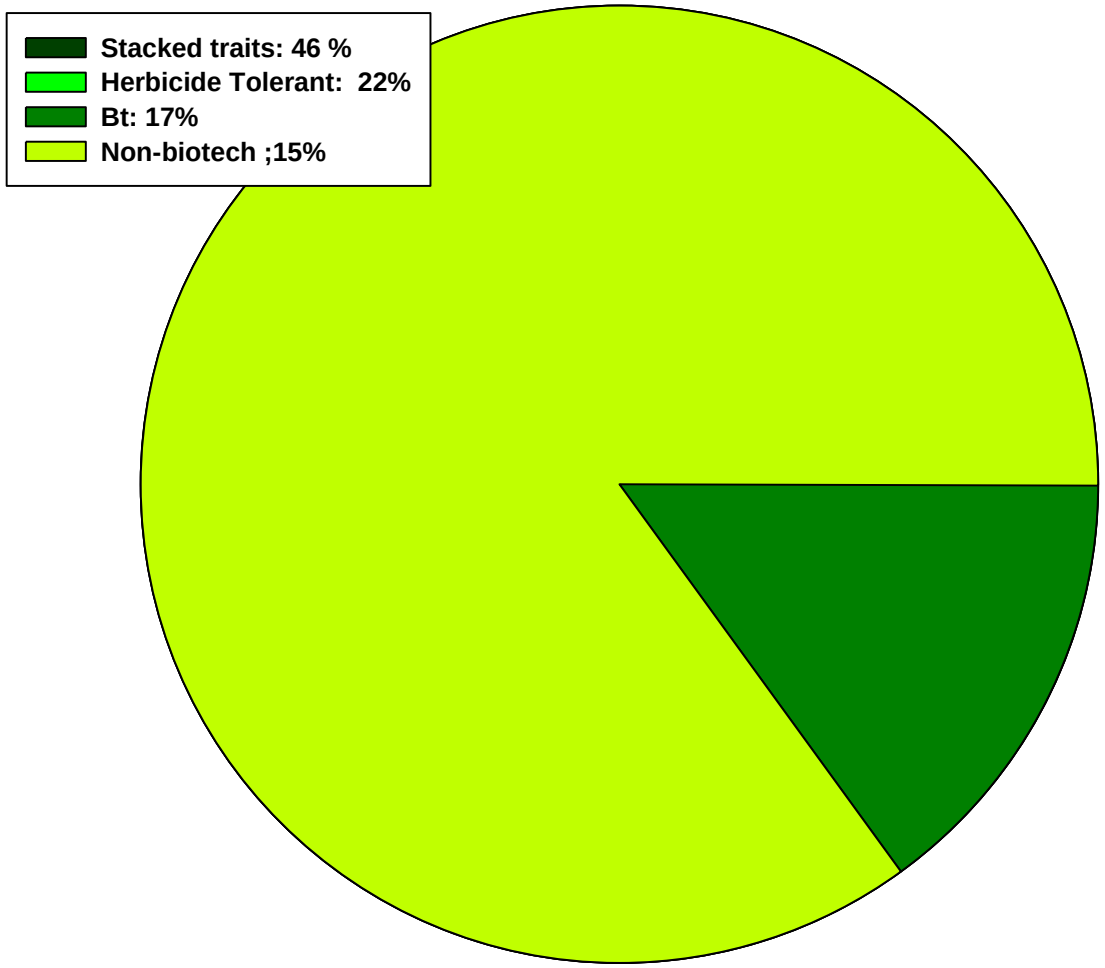
Agricultural Productivity, Land Use and Species Preservation

"…the extremely rapid growth in commercially-grown transgenic crops has almost entirely taken place on the back of four crops (soybean, cotton, maize and rapeseed) and four transgene types (insect resistance conferred by *Bacillus thuringiensis* (*Bt*) *cry1* and *cry3*, and herbicide tolerance conferred by *bar* or *pat* (glufosinate resistance) and modified *EPSPS* (glyphosate resistance))."

M. Wilkenson and M. Tepfer. Environ. Biosafety Res. 8(2009)1-14.

The use of varieties with biotech traits in the US in 2009.

(NCGA www.worldofcorn.com)



US Corn Acres (2009)/ 86.5M

Agricultural Productivity, Land Use and Species Preservation

Results:

- **Globally, adoption of GE crops produces significant yield improvements,**
- **Estimated yield gains from GE seeds are greater in developing than in developed countries, especially where pest pressure is greatest,**
- **Yield gains are expected to be greater with GE crops than non-GE crops in the future.**
- **"Absent the intensification permitted by agricultural biotechnology, an estimated additional 20 M ha of land would have been required to produce the 2008 harvest of staple crops."**

Sexton and Zilberman, 2010

CAN BIOFUELS IMPROVE WELL-BEING IN DEVELOPING COUNTRIES?

"Successful bioenergy industries bring significant job creation potential … and … because the vast majority of bioenergy employment occurs in farming, transportation and processing, most of these jobs would be in rural areas."

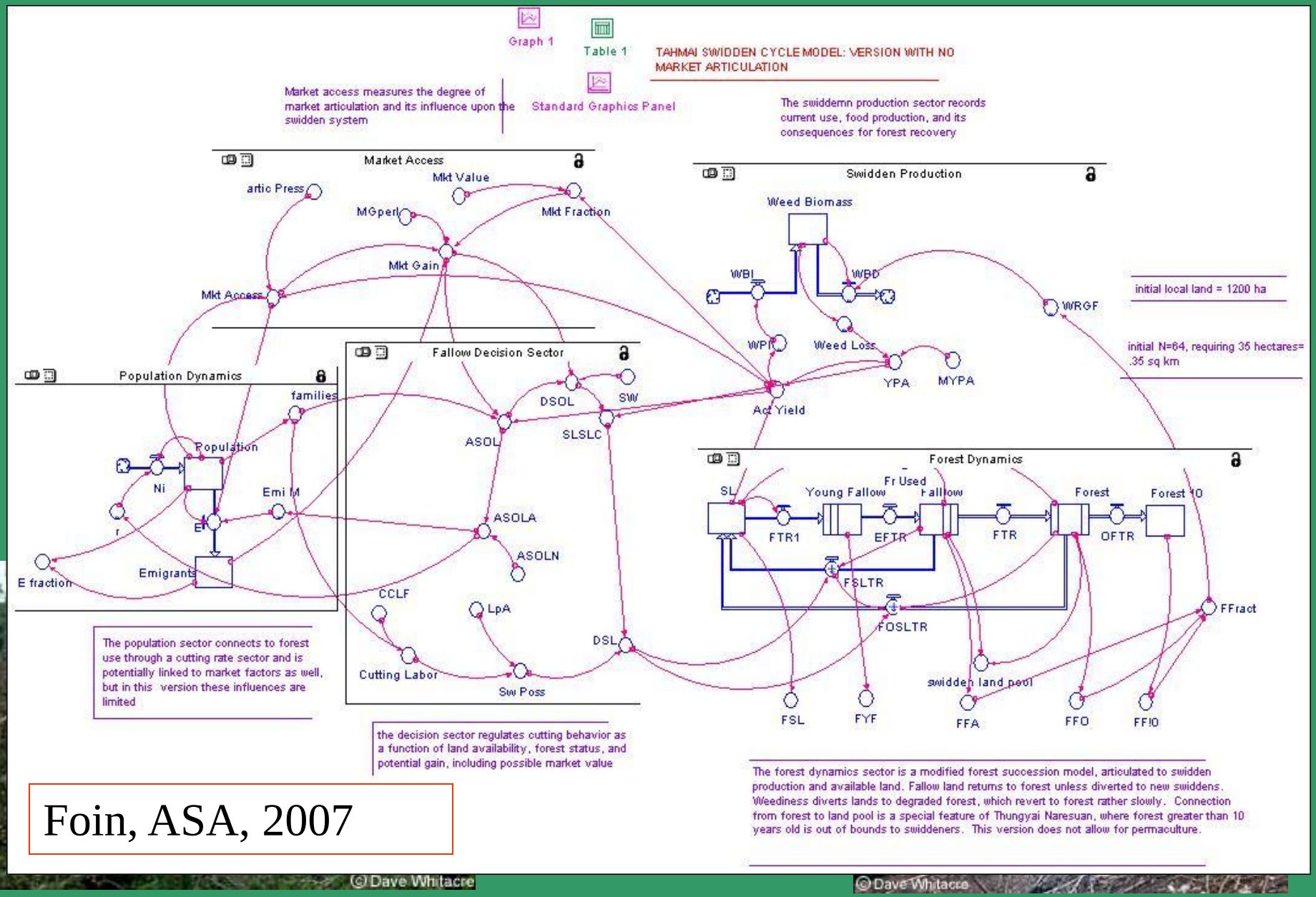
United Nations, 2007. Sustainable Bioenergy for Decision Makers

"Many developing countries have seen their domestic agriculture economy …destroyed because of dumping of subsidized grain surpluses into their market…which undercut domestic producers,…therefore many farmers stopped tilling their land and became dependent on food imports. Biofuels …take away the risk of subsidized surpluses and allow the agriculture of developing countries to flourish…

Biofuel production is a twofold chance for developing countries: It makes them less dependent on energy imports and revitalizes their domestic agriculture."

Robert Vierhout_Global Economic Symposium http://www.global-economic-symposium.org/solutions/the-global-environment/food-versus-fuel/strategyperspectivefolder/the-food-bio-fuel-hype

Site-specific analysis of LUC, NE Thailand



Foin, ASA, 2007

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Agricultural Productivity, Land Use and Species Preservation

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"Most crop plants produce pollen, and pollen can be carried by wind, insects, animals or other vectors to distant locales where they may successfully pollinate a waiting recipient. The recipient could be another plant of the same species, a different (GM or non-GM) cultivar, or it could be a compatible relative, with or without weedy characteristics."

"**The main ecological hazard …is genetic proliferation and spread beyond intended borders**. Increased ecological fitness (of weeds) is a real hazard and warrants …research. But not all GM genes confer fitness traits, and many fitness (or 'weedy') characteristics appear in non-GM plants. **Depending on the nature of the gene and the recipient, the resulting hybrid may or may not cause concern.**"

A. Mchughen, Environ. Biosafety Res. 5(2006)1-2.

Agricultural Productivity, Land Use and Species Preservation

"…the assumption that only GMO plants pose hazards from gene escape must be challenged. All of the ecological damage wrought on the planet to date has shown non-GMOs to be responsible,

…Ecosystems are threatened by introductions of species from elsewhere, from natural invasions and successions and from expanding human intrusions (especially ordinary agriculture and urbanization).

Focusing on one small component (GMO agriculture) means that we overlook the true threats to ecology and biological diversity."

A. Mchughen, Environ. Biosafety Res. 5(2006)1-2.

Agricultural Productivity, Land Use and Species Preservation

"The … inexorable expansion of global human population size, significant increases in the use of biofuel crops and the growing pressures of multifunctional land-use have **intensified the need to improve crop productivity.**

The widespread cultivation of high-yielding genetically modified (GM) crops could help to address these problems, although in doing so, **steps must also be taken to ensure that any gene flow from these crops to wild or weedy recipients does not cause significant ecological harm."**

M. Wilkenson and M. Tepfer. Environ. Biosafety Res. 8(2009)1-14.

Agricultural Productivity, Land Use and Species Preservation

"…much of the research …has focused on predicting changes to the **fitness** of the crop, of a wild relative, or of an associated species, that could lead either to population expansion or contraction. In this sense, **any change in fitness *per se* has been used as a proxy for the consequences that may arise from the changed fitness**.

However,…, it does not necessarily follow that changed fitness will lead to a change in population size, that a change in population size will necessarily lead to harm, that harm cannot occur without a change in population size, or that the context in which we measure fitness necessarily relates to the acceptable/unacceptable boundary (for change) being considered"

M. Wilkenson and M. Tepfer. Environ. Biosafety Res. 8(2009)1-14.

Agricultural Productivity, Land Use and Species Preservation

"…To date **there has been little consistency in the meaning of the phrase 'enhanced fitness' when applied to risk studies associated with the release of transgenic crops.** "

M. Wilkenson and M. Tepfer. Environ. Biosafety Res. 8(2009)1-14.

Agricultural Productivity, Land Use and Species Preservation

"…the GMO-regulatory system will soon be facing a greater diversity of GMO crop species, including ones expressing **transgenes that will directly affect important ecological parameters such as resistance to major biotic and abiotic stresses**. It is clear that **this will place extraordinary stress on the regulatory system**, making it particularly important to clarify, and wherever possible to simplify, how the environmental impact of GMO crops is assessed."

M. Wilkenson and M. Tepfer. Environ. Biosafety Res. 8(2009)1-14.

Agricultural Productivity, Land Use and Species Preservation

If this is not done in a timely fashion, there could be two highly negative consequences:

First, this could lead to refusal to deploy GM crops that are clearly of great practical use, and

second, if the crops in question are of over-riding importance for the agricultural or broader economy, the inability of the current system to deal with risk assessment may have the effect of leading to wholesale dismantlement of … present regulatory oversight."

M. Wilkenson and M. Tepfer. Environ. Biosafety Res. 8(2009)1-14.

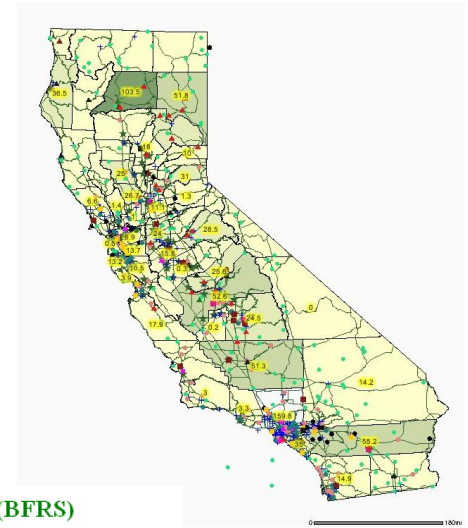
Agricultural Productivity, Land Use and Species Preservation

There are important benefits from the use of agricultural biotechnology. These include higher yields and overall greater resource use efficiency in crop production, and lower emissions from farms. They allow less land to be used to meet human needs for food, feed, fiber and now fuels.

There are also risks that unwanted traits will find there way into wild species, and affect natural ecosystems in undesirable ways. This may be more important with respect to new traits that increase resistance to biotic and abiotic stresses than current traits, mostly for herbicide resistance. This will challenge current regulatory processes but careful, objective work is needed to insure achieving the benefits from these technologies without excessive ecological risk.

California Biomass Collaborative

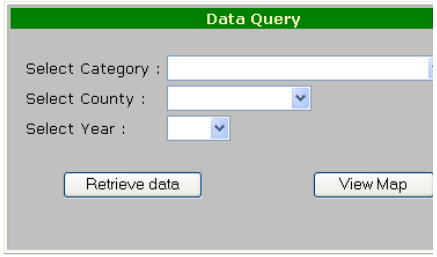
- Statewide biomass coordinating group
- Biomass Facilities Reporting System
- Biomass resource assessments
- Technology assessments
- Planning Functions/Policy
  - Needs Assessment
  - Roadmap for biomass development
- Coordination with State Bioenergy Interagency Working Group



California Biomass Facilities Reporting System (BFRS)
Power Generation Assessments

The BFRS database contains Biomass power plants and related facilities, including thermal station power plants, digesters, landfill gas systems, fermentation plants, bio refineries, other biomass energy converters, material handling and processing operations, and storage units with technical and environmental performance. Gross and technical resources, estimates of electricity capacity and energy from biomass for year 2003, 2005,2007, 2010 and 2017 are included in this database.

Specific information can be retrieved by following steps.



California Biomass Facilities Reporting System (BFRS)
Resource Assessments

The BFRS database contains Biomass power plants and related facilities, including thermal station power plants, digesters, landfill gas systems, fermentation plants, bio refineries, other biomass energy converters, material handling and processing operations, and storage units with technical and environmental performance. Gross and technical resources, estimates of electricity capacity and energy from biomass for year 2003, 2005,2007, 2010 and 2017 are included in this database.

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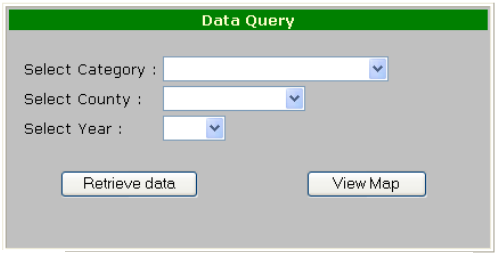

http://biomass.ucdavis.edu
Email: biomass@ucdavis.edu

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Multi-scale Integrated Analysis of Agroecosystems

M. Giampietro

2004, CRC Press